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Exploring Resource Efficiency Benchmarks for Environmental Sustainability

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Recommended Citation

Zhang, J. J., Joglekar, N. R., & Verma, R. (2012). Exploring resource efficiency benchmarks for environmental sustainability [Electronic version]. *Cornell Hospitality Quarterly*, 53(3), 229-241. Retrieved [insert date], from Cornell University, School of Hospitality Administration site: <http://scholarship.sha.cornell.edu/articles/47/>

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Exploring Resource Efficiency Benchmarks for Environmental Sustainability

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Keywords

resource efficiency, benchmarking, environmental sustainability; exploratory factor analysis

Disciplines

Hospitality Administration and Management

Comments

Required Publisher Statement

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Exploring Resource Efficiency Benchmarks for Environmental Sustainability in Hotels

Cornell Hospitality Quarterly
53(3) 229–241
© The Author(s) 2012
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sagepub.com/journalsPermissions.nav
DOI: 10.1177/1938965512441165
<http://cqx.sagepub.com>



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Abstract

Successful environmental sustainability (ES) initiatives aim for simultaneous environmental and economic benefits. Benchmarking these initiatives must therefore account for environmental and economic outcomes. To this end, the authors propose to construct a cost-based resource efficiency measure for ES from reported financial data. This approach links the environmental and economic performance outcomes by extracting information from resource related expenses normalized by RevPAR (revenue per available room). Through exploratory factor analysis of an eight-year panel of 984 U.S. hotels, the authors identified two factors that drive resource efficiency in hotel operations, one of which is operations-centered and the other customer behavior-centered. This two-factor measure quantifies the weights that operations and customer behavior contribute to resource efficiency and measures the systematic variations across key hotel operating characteristics. Such resource efficiency benchmarks complement the practice-focused environmental management systems developed by individual hotel companies and guidelines proposed by government agencies such as the U.S. Environmental Protection Agency.

Keywords

resource efficiency, benchmarking, environmental sustainability, exploratory factor analysis

U.S. hospitality industry leaders consistently rank sustainability among their top concerns (Center for Hospitality Research [CHR] 2009, 2010, 2011). Correspondingly, practices aimed at cultivating green lodging operations have flourished. Simple measures such as linen and towel reuse programs are ubiquitous (American Hotel and Lodging Association [AH&LA] 2010), and sophisticated information technology (IT)-enabled environmental management systems are at various stages of implementation among hotel chains (Hilton 2011; IHG 2011). However, sustainable development remains a critical challenge in hospitality (Deloitte 2010), and one particular issue is the lack of consistent industry reporting standards (Ricaurte 2011, 2012). We propose that an industry-wide environmental sustainability (ES) measure, which captures both economic and environmental performance of ES initiatives, will help address the industry reporting issue. In this article, we present such a measure using large-scale financial data.

We operationalize the measurement of ES in terms of resource efficiency—the total cost of resources (e.g., electricity, water, and materials) used to produce one unit of revenue. This operationalization echoes the “productivity” emphasis in United Nations Millennium Development Goal #7 on sustainable development—“to ensure that the overall productivity of accumulated human and physical capital resulting from development actions more than compensates for the direct or indirect loss or degradation of the environment”

(United Nations 2000). Under this premise, this article addresses the following two research questions:

1. How can a measure of ES be developed by understanding the common factors driving the cost-efficiency of consuming fundamental resources such as utilities and materials in hotel operations?
2. Can this ES measure identify patterns along key dimensions of hotel characteristics including chain segment, operating structure and location, and over time?

We apply exploratory factor analysis to five resource-related expense items (normalized by revenue per available room [RevPAR]) in the operating statements of 984 U.S. hotels over an eight-year period (2001–2008). We find that hotels’ resource consumption patterns can be expressed in

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two common factors. We term one factor *operations-centered* and the other *customer behavior-centered*. The operations-centered factor gives higher weights to utility costs and “maintenance other” expenses; while customer behavior-centered factor gives higher weights to laundry, linen, and supplies (LLS) used in the rooms, as well as food and beverage (F&B) departments. (As we explain below, “maintenance other” is a category in the Uniform System of Accounts, used by U.S. hotels. This framework would apply to any hotel.) These two weighted factor scores indicate individual hotels’ relative resource efficiency. We find systematic variation in the factor scores along chain segments, operating structures, and locations.

Next, we briefly review two research areas that provide the theoretical basis for our resource efficiency-based approach to measuring ES in service operations. The first body of literature underscores the importance of the economic-environmental balance of ES. The review of the second research stream explicates how service coproduction may affect environmental initiatives.

Theoretical Background

Green Pays or Pay-to-be-Green? Metrics Needed

The strategy literature offers two opposing views on the economic-environmental performance impact of ES. Porter and van der Linde (1991, 1995) argued that improving environmental performance reduces waste and increases productivity, thus improving corporate performance—that is, being green pays. Walley and Whitehead (1994) argued that environmental initiatives that systematically increase profitability are rare and that managers must acknowledge the trade-offs between economic competitiveness and environmental protection—that is, companies pay to be green. This *green pays* versus *pay-to-be-green* controversy has persisted as empirical researchers have presented inconsistent findings (Dowell, Hart, and Yeung 2000; King and Lenox 2001a, 2001b, 2002; Ambec and Lanoie 2008).

We argue that the lack of standardized metrics of ES plays a fundamental role in this controversy. Idiosyncratic measures make it difficult to compare findings and generalize across studies. For example, researchers have operationalized the construct of environmental performance distinctively, ranging from the adoption of environmental management systems or standards (Corbett and Kirsch 2001; Melnyk, Sroufe, and Calantone 2003) to the announcements of environmental awards or crises (Klassen and McLaughlin 1996). In the absence of an industry standard (Unruh and Ettenson 2010), leading hotel chains have developed proprietary environmental management systems that report and analyze the environmental impact of their hotel operations (Hilton 2011; IHG 2011). Environmental

certification programs and government guidelines also contain idiosyncratic features, resulting in significant confusion over environmental reporting (Ricaurte 2011, 2012).

We propose to measure ES through analysis of an existing hotel financial reporting system. Using a dimension-reduction statistical method, we extract information from large-scale data on revenue and resource expenses. This approach emphasizes reducing the consumption of key resources per unit of revenue generated, and thereby moves ES issues into the operating purview of managers. More importantly, this efficiency focus allows the economic and environmental aspects of sustainable development to be simultaneously evaluated, yielding consistent information necessary for the dialogue between the green-pays and pay-to-be-green camps. We recognize that this approach does not capture all aspects of sustainability (e.g., life cycle impact of material used or externalities felt by the local and global community) because of its basis on internal financial and operations data.

Service Coproduction: Operations and Customers Both Matter

While some scholars have appreciated customers’ essential role in productivity improvement (Lovelock and Young 1979), sustainability research has focused on the supplier side almost exclusively. Two historic reasons may have contributed to this bias. First, sustainable operations researchers began investigating ES in manufacturing settings, focusing on how to coordinate and optimize the reverse logistics coming back from the point of consumption (Guide, Harrison, and Van Wassenhove 2003; Guide and Van Wassenhove 2006) and how to capture the residual value in rework or end-of-life products by building closed-loop supply chains (Guide, Harrison, and Van Wassenhove 2003; Savaskan, Bhattacharya, and Van Wassenhove 2004; Guide and Van Wassenhove 2006; Linton, Klassen, and Jayaraman 2007). In these manufacturing settings, individual customers select and consume the outputs but do not contribute inputs specific to the production processes (Sampson 2001), thus having no direct impact on resource consumption during production. However, in service processes, customer inputs are, of course, a part of the actual service being delivered, thus directly affecting the resource efficiency of the process.

Second, service research has long perceived customers as a source of variability in the service processes (Chase 1981; Chase and Tansik 1983). To minimize the negative effect of variability introduced by customer contact, a decoupling approach to service design suggests that processes with higher customer contact (i.e., front-office operations) should aim to maximize effectiveness and that processes with low customer contact (i.e., back-office operations) should aim to maximize efficiency (Silvestro et al.

1992; Metters and Vargas 2000). We argue that customers can be a valuable source of resource efficiency. For example, hotel management may decide to install energy-efficient lighting and equipment, but the amount of electricity consumed also depends on customers' turning off the lights and lowering the settings before they leave their hotel room. Therefore, sustainable resource management should be a concerted effort between the front- and back-office operations.

Emerging research in sustainable service operations has underscored the importance of managerial decisions and customer behavior in sustainable development. For instance, survey research has found that managerial perceptions of the environment as a competitive opportunity is essential for ES investment (López-Gamero, Claver-Cortés, and Molina-Azorín 2011). In controlled experiments, customers voiced their support for various energy-conservation technologies (Susskind and Verma 2011). Case evidence showed that guest involvement in conservation and recycling makes both environmental and economic sense (Enz and Sigauw 1999). Developing an ES measure from large-scale secondary data supplies the metrics to gauge the economic and environmental outcomes of service coproduction.

To summarize, we propose to benchmark ES by building on two prominent features of ES in service settings. Specifically, we track both economic and environmental performance of service operations, and we measure resource efficiency service coproduction.

Method

In this section, we describe our empirical study and the exploratory factor analysis (EFA) method used to develop the ES benchmark. We first describe the dataset and variables selected for EFA, and then explain the steps for identifying the two factors. Finally, we investigate how these two resource efficiency factors relate to key dimensions of hotel characteristics through a series of cross-sectional and longitudinal comparisons.

Sample and Data Collection

Our study required a representative dataset that consistently tracks operating expenses and revenues at the hotel unit level over an extended period of time. To this end, we engaged PKF Hospitality Research (PKF-HR) as our data partner. Since 1936, PKF-HR has collected property-level year-end operating statements from thousands of hotels across the United States and put them into a format conforming to the Uniform System of Accounts for the Lodging Industry (USALI) to ensure equitable benchmarking. Our sample consists of operating statements tracking two hundred specific revenue and expense items in 984 hotel properties located in forty-eight states and Washington,

D.C., from 2001 to 2008 (total observations = 7,872). (The two U.S. states not represented are South Dakota and North Dakota.) This sample represents all major hotel chains, property types, and geographic locations, as well as various degrees of urbanization. Because we are interested in the relationship between the underlying common drivers and location characteristics (e.g., weather and degree of urbanization) of the hotels, we supplement the hotel dataset with historical climate data at the state level (NOAA 2010) and population density by zip code derived from the U.S. census (U.S. Census Bureau 2002).

About 70 percent ($n = 697$) of the hotels in our sample are run under a franchise or by chain operators, and the remaining 30 percent ($n = 287$) are run by third-party management companies. Hotels in both groups span the five tiers of chain segments (i.e., lower tier, midtier without F&B, midtier with F&B, upper tier without F&B, and upper tier with F&B). Slightly less than half of the hotels offer on-site F&B service.

To verify the representativeness of our sample, we compared the sample hotels with the 2009 national lodging industry profile compiled by AH&LA in terms of income mix (leisure of business travelers), occupancy rate, property size, geographic distribution, and RevPAR. Exhibit 1 presents the comparison.

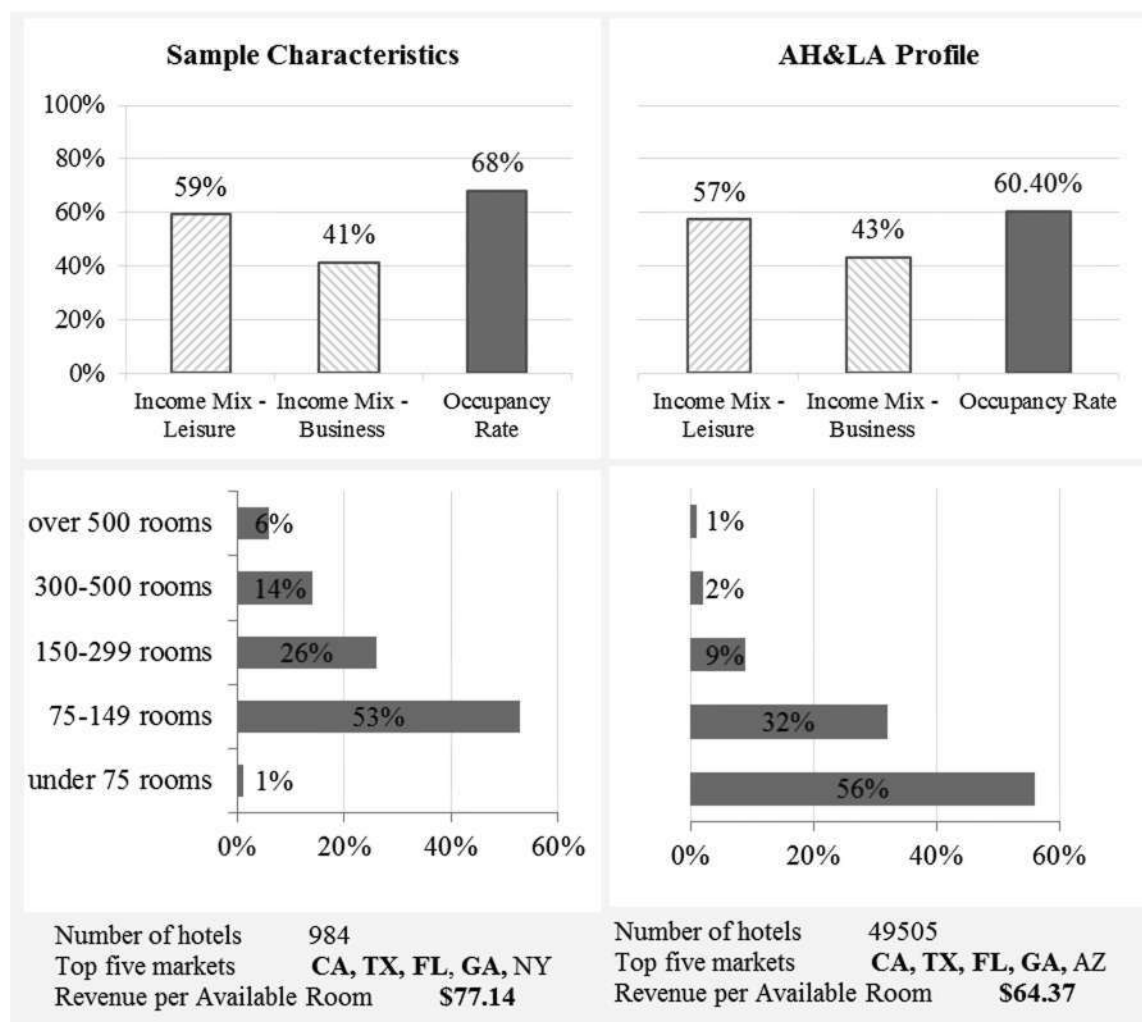
Our sample appears to be representative in terms of income mix, geographic distribution, and occupancy rate. In the AH&LA survey, the smaller hotels (with less than seventy-five rooms) constitute the majority (56 percent), while the hotels included in our sample operate at a larger scale with higher RevPAR than the national average. Therefore, our findings should be interpreted accordingly and may not generalize to the entire U.S. hotel population. It is worth pointing out that this bias towards larger and better-performing hotels could be an advantage in investigating best practices in ES because research has shown that managers in chain-affiliated hotels were generally more likely to pay attention to environmental issues than were independent operators, many of whom run small properties (Bohdanowicz 2005).

Variables: Resources and Supplies Consumed in Hotel Operations

Our goal is to construct normalized resource efficiency benchmarks for hotel operations. An online tool with similar aim at energy benchmarking is the Energy Star Portfolio Manager (U.S. Environmental Protection Agency 2011), which requires collection and input of utility data as well as some basic information about the building and its use at individual hotel sites (see Ricaurte 2012). The Energy Star Portfolio Manager produces a percentile, based on the building's greenhouse gas emissions (including carbon dioxide, methane, and nitrous oxide) from on-site fuel combustion

Exhibit 1:

Sample hotel characteristics (2008) compared with the American Hotel and Lodging Association (AH&LA) national profile (2010)



and purchased electricity to district heating and cooling. Recognizing that hotels are resource intensive in water and materials in addition to energy, we derive cost measures from the following five USALI accounts recorded in operating statements by each hotel property: electricity, water and sewer, "maintenance other" expense, LLS for the rooms department, and separately for the F&B department.¹

Exhibit 2 presents an overview of the average RevPAR of the hotels in our dataset from 2001 to 2008 (discounted to 2008 dollars using Consumer Price Index inflation calculator [U.S. Bureau of Labor Statistics 2010]), and the sum of the five expenses as a percentage of the RevPAR for the same period. These data show the resource intensity of F&B services. The chain segments without F&B spend 11 to 12 percent on utilities and supplies, while the segments with F&B incur about 50 percent more expense in those categories.

Exhibit 3 shows the yearly trend of these five expenses as percentage of RevPAR. Except for F&B LLS, all the other expenses display an upward trend. Since 2006, we observe a large increase in the rooms' LLS expenses. Electricity and water expenses each experienced about 0.5 percent of RevPAR increase in the eight-year period, possibly a result of rising utility costs in recent years.

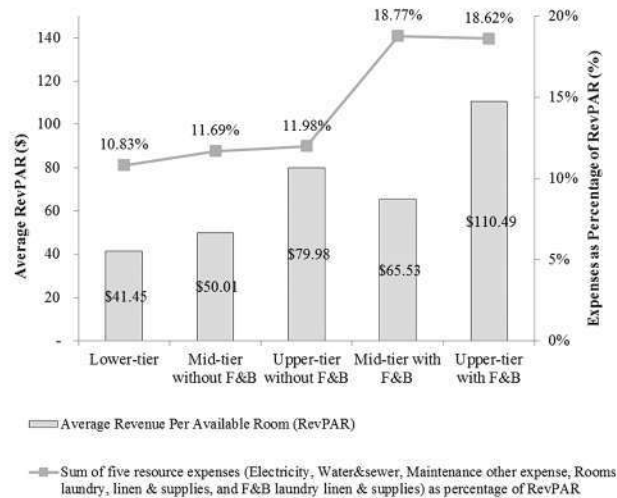
In the following section, we apply EFA to these resource expense items to condense the information into fewer factors for further investigation.

Research Methodology: Exploratory Factor Analysis

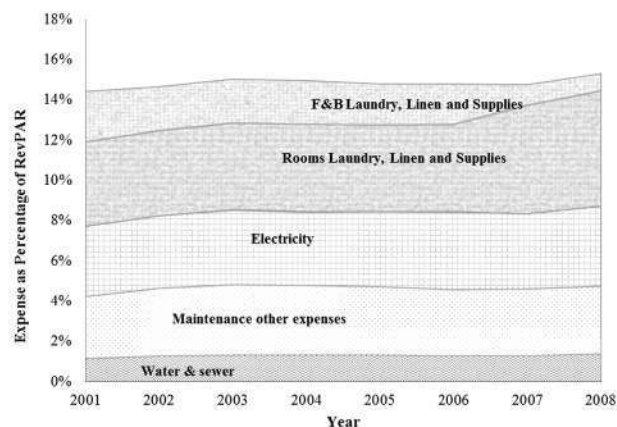
EFA is a multivariate data analysis method that can be used to analyze the interrelationships between a large number of correlated observed variables and condense the information

Exhibit 2:

Resource expenses as a percentage of revenue per available room (RevPAR) across chain segments

**Exhibit 3:**

Annual average resource expenses as a percentage of revenue per available room (RevPAR) (2001–2008)

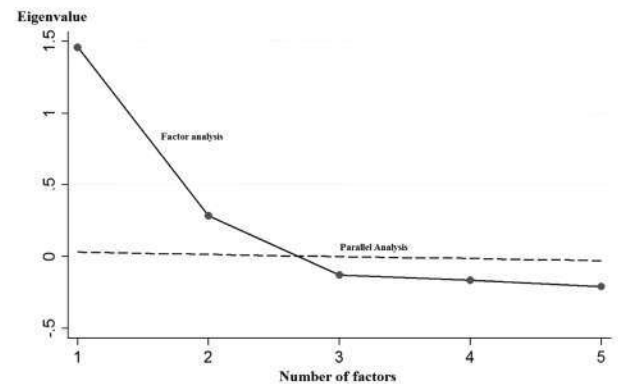


in the original group of variables into fewer indices (factors) with minimum loss of information (Hair et al. 1995). The predicted factor score, which is a weighted sum of the observed variables, can then be used in further analysis to understand the distribution of the observations and investigate the decisions leading to the observed varying patterns.

The first step of EFA is to determine the number of factors to retain according to the variability explained. Researchers have found parallel analysis to be a superior method to determine the number of factors to retain in EFA (Ledesma and Valero-Mora 2007). Exhibit 4 shows the parallel analysis results from the STATA program *fapara* (Hayton, Allen, and Scarpello 2004). The dashed line for

Exhibit 4:

Parallel analysis indicates two factors should be retained

**Exhibit 5:**

Factor Loading Results from Exploratory Factor Analysis

Expense variables	Factor 1 (customer behavior-centered)	Factor 2 (operations- centered)
Electricity expense (% of revenue per available room [RevPAR])	.13	.59
Water and sewer expense (% of RevPAR)	-.18	.55
Maintenance other expense (% of RevPAR)	.38	.43
Rooms' laundry, linen, and supplies (LLS) expense (% of RevPAR)	.57	-.05
Food and beverage service (F&B) LLS expense (% of RevPAR)	.60	-.12

parallel analysis in the graph crosses the solid PCA (principal components analysis) line before reaching the third component; therefore, two factors should be retained.

Exhibit 5 shows the loadings corresponding to the two factors retained. The loadings are the weights for calculating the factor scores (i.e., the weighted sum of the observed variables). The loadings in Exhibit 5 meet the guidelines for item-to-factor loadings suggested by Comrey and Lee (1992). The loadings for electricity, water and sewer, rooms LLS, and F&B LLS are all above .55 (good), and the loading for "maintenance other" expense on Factor 2 is .43 (fair).

The second step of EFA is to assign managerially relevant meanings to the factors. We observe that the rooms' and F&B LLS expenses load heavily on Factor 1, but only lightly on Factor 2. The AH&LA's 2010 Lodging Survey found that nearly 90 percent of the hotels surveyed have a linen and towel reuse program. It follows that customers have a strong influence on the usage of linens, towels, and

supplies, which contributes heavily to Factor 1, as reflected by the high loadings. Therefore, we name Factor 1 the Customer Behavior–Centered Cost Factor (CBCF). The almost equal coefficients for rooms LLS and F&B LLS regarding CBCF confirm this classification because the same hotel customers drive both expenses.

The electricity and water expenses load more heavily on Factor 2 than on Factor 1. Research of historic data revealed that hotel utility costs consistently ranged from 3.5 to 4.5 percent of total revenue in this highly cyclical industry (Mandelbaum 2004), suggesting that hotel management can influence them through operational changes. For instance, hotel management may reduce energy consumption by installing energy-efficient lighting and equipment, training staff, and implementing operating procedures such as setting thermostats to low energy settings when a room is empty. Similarly, hotel management may reduce water usage significantly by installing low-flow shower heads and dual-flush toilets, enforcing specific thawing procedures, and installing rain sensors. Therefore, we name Factor 2 the Operations-Centered Cost Factor (OCF).

The “maintenance other” expense refers to the costs associated with the day-to-day upkeep of a hotel, which are assigned to the property operations and maintenance (POM) department. Therefore, the “maintenance other” expense captures the wear and tear due to hotel customers’ activities and hotel operators’ maintenance operations, as indicated by the similar loadings on CBCF (.43) and OCF (.38).

We note that benchmarking ES using revenue-normalized cost data has several advantages over the direct measurement of resource consumption (each resource in its own unit) by measuring resources in a common unit (dollars, in this case). First, because we operationalize ES in terms of the reduction in resource consumption per unit of revenue generated, the resulting benchmark addresses the balance between environmental and economic performance. Second, the reported financial data ensures that the resulting benchmark is high-quality, consistent, and comparable across properties. Finally, this measure comprehensively captures the range of costs involved in sustainable development. For instance, keeping equipment in top condition saves electricity (dollars/kilowatt-hour) but incurs maintenance cost (dollars). Being weighted sums of a wide range of resource expenses, these two factors capture the influence from both operations and customer behavior regarding ES.

The third step of EFA is to generate the load factor scores (i.e., weighted sums of the five observed variables) for each hotel property based on the loadings (i.e., weights). These load factor scores are numerical values that rank a hotel’s standing on each of the underlying factors. We apply the Bartlett estimation method, a weighted least squares method that gives less weight to variables with lower loading on the factor (Pett, Lackey, and Sullivan 2003), to predict the load factor scores in this study. This choice is supported by two

considerations: (1) the interpretation of the factors is based on the factor pattern (Beauducel 2005), and (2) the method possesses superior ability to approximate true factor scores (Ambrosino 1973). The values are scaled such that the mean for each factor is zero and the sum of squares of the unique factors over the range of variables is minimized (Harman 1976). A negative factor score indicates higher than average resource efficiency (i.e., use less than average for the same revenue generated); a positive score, on the other hand, indicates lower than average efficiency.

In summary, our resource efficiency–based ES benchmark consists of two factors: the OCF and the CBCF. Using the factor scores (weighted sum) for individual hotels, we are now able to quantify a hotel’s relative standing in ES. Next, we analyze the relationship between the ES factor scores and key hotel characteristics and show how to use the measures to benchmark sustainable development.

Comparing ES across Hotel Characteristics

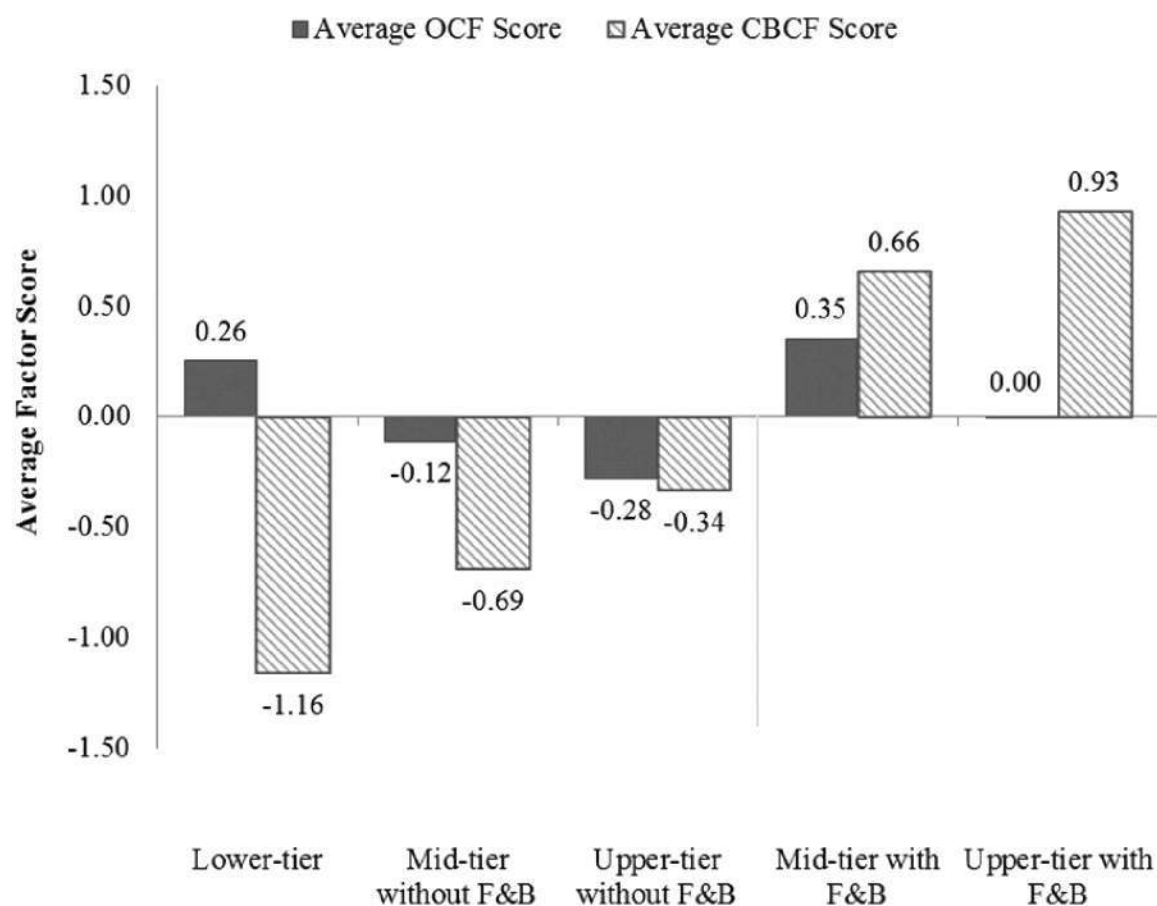
In this section, we perform cross-sectional and longitudinal comparisons using the two-factor ES measure (i.e., OCF and CBCF scores). The hotel characteristics being investigated include chain segment, operating structure (franchise or chain operator vs. management company), and location-related characteristics such as climate and degree of urbanization. These characteristics relate to fundamental choices regarding positioning, governance, and location in hotel management.

Relationship between ES Scores and Chain Segment

Hotel chain market segments are classified by the scope of amenities and level of service provided. Exhibit 6 shows the variation in factor scores across five chain segments. We make three observations from this graph. First, the two chain segments with F&B (on the right of the graph) scored higher for both OCF and CBCF than the other three segments, without F&B (on the left). This observation is consistent with the finding from Exhibit 2, where the sum of the five expenses after normalized by RevPAR is at least 50 percent more for hotels with F&B than those without F&B. This demonstrates that resource-intensive F&B services affect both OCF and CBCF. Second, within each subgroup (without F&B or with F&B), as one moves up the chain scale, the OCF scores decrease, indicating increasing resource efficiency in operations. Third, the opposite is true for CBCF scores within each subgroup (without F&B or with F&B): as one moves up the chain scale, the CBCF scores increase, indicating decreasing resource efficiency driven by customer behavior.

Exhibit 6:

Environmental sustainability (ES) factor scores across five chain market segments

**Exhibit 7:***t*-Tests Comparing Environmental Sustainability Factor Scores for Hotels under Different Operating Structures

	Franchise/chain operator (N = 697)	Management company (N = 287)	One-tailed <i>t</i> -test <i>p</i> -value
Mean of operations-centered cost factor (OCF) score	-.058	.142	.030
Mean of customer behavior-centered cost factor (CBCF) score	-.197	.480	.000

Relationship between ES Scores and Operating Structure

Exhibit 7 compares the eight-year average factors scores for hotels operated by franchise or chain operators and those operated by management companies. The last column displays the *p*-values from a one tailed *t*-test of the mean differences. Hotels managed by franchise or chain operators scored significantly lower for both OCF and CBCF, indicating higher resource efficiency in both dimensions.

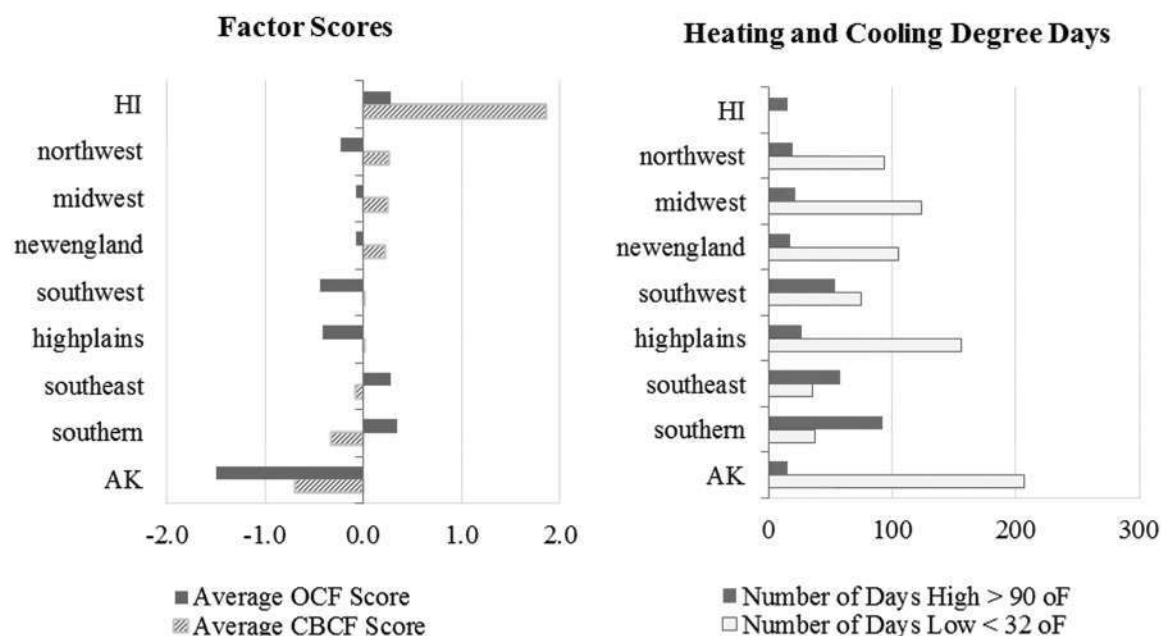
Relationship between ES Scores and Location: Climate and Urbanization

Location is fundamental for real estate investments such as hotels. From a resource efficiency perspective, location-based characteristics such as annual heating and cooling degree days and extent of urbanization are central.

First, we examine the average factor scores for nine U.S. climate zones, as shown in Exhibit 8. The bar chart on the left displays the OCF and CBCF across those nine zones. The bar graph on the right shows the heating and

Exhibit 8:

Environmental sustainability (ES) factor scores for nine U.S. climate zones

**Exhibit 9:**

T-tests Comparing Environmental Sustainability Factor Scores for Hotels in Locations with Different Degrees of Urbanization

	Rural/suburban (less than 1,000 persons per square kilometer) (N = 526)	Urban (1,000 persons or more per square kilometer) (N = 458)	One-tailed t-test p-value
Mean of operations-centered cost factor (OCF) score	.101	-.116	.003
Mean of customer behavior-centered cost factor (CBCF) score	-.020	.018	.328

cooling degree days, with the red bars representing the number of very hot days (high above 90°F) and white bars representing the number of very cold days (low below 32°F). Overall, there are markedly different resource efficiency patterns for hotels in different climate zones. However there is no obvious correlation between the resource efficiency profiles of the hotels on the left and the climate on the right. It is somewhat surprising to see that hotels in Hawaii (HI) are much less efficient in both CBCF and OCF than those in Alaska (AK), in spite of Hawaii's mild climate. This shows that energy is just one component of the total resource needs of hotels. Other hotel operating characteristics, such as property type and number of rooms, may have affected the resource efficiency measures.

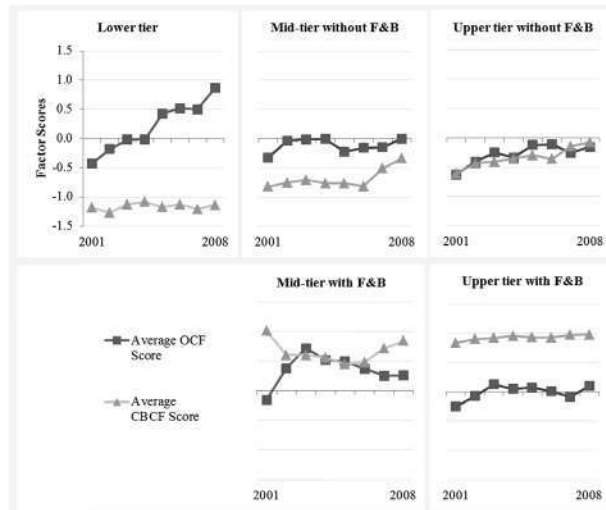
Second, we examine how variations in urbanization (as measured by population density) relate to resource efficiency. Exhibit 9 compares the eight-year average factor

scores for hotels in rural or suburban areas and those in urban settings. The last column displays the *p*-values from a one-tailed *t*-test of the mean differences. Urban hotels are significantly more efficient in OCF. External factors such as fierce competition and higher incentive to conserve energy due to resource scarcity may have contributed to the operational advantage of the urban hotels. The behavior-centered resource efficiency measures are essentially the same between the two groups.

Longitudinal Analysis of ES Scores and Hotel Characteristics

Changes in the factor scores over time contain useful information for managing ES initiatives, because the changes highlight the overall industry trend in sustainable development. First, we present longitudinal analysis of the resource efficiency measure across chain market segments (Exhibit 10).

Exhibit 10:
Longitudinal change in environmental sustainability (ES)
factor scores by chain segment



Between 2001 and 2008, the U.S. hotel industry experienced two sharp downturns, one following 9/11 in 2001 and the other after the housing bubble burst in 2006 (Smith 2010). Exhibit 10 displays the time trend of the OCF and CBCF scores in each of the five chain market segments. We make two observations. The CBCF scores display larger between-segment differences, but do not vary much over time within each chain segment. In particular, the chain segments at two opposite ends, lower tier and upper-tier with F&B, show flat CBCF scores. The OCF scores, on the other hand, display moderate between-segment differences, but vary over time within each chain segment. These patterns suggest that resource efficiency of operations is more sensitive to industry cycles, and decreases during industry downturns.

We compare the time trend of OCF and CBCF for hotels operated by the franchise or chain operators and those operated by management companies in Exhibit 11. Overall, hotels operated by management companies scored higher on both factors, indicating lower resource efficiency. For operations-centered resource efficiency, we again observe its sensitivity to industry cycles—efficiency decreased in 2001–2003 and again in 2007–2008. For CBCF scores, the franchise or chain-operated hotels are consistently more efficient.

To summarize, we conducted a series of subgroup comparisons of the two-factor ES measure, both cross-sectionally and longitudinally. The varying resource efficiency profiles depicted in the exhibits demonstrate that this two-factor ES benchmark is a valid and reliable measure of ES for hotels.

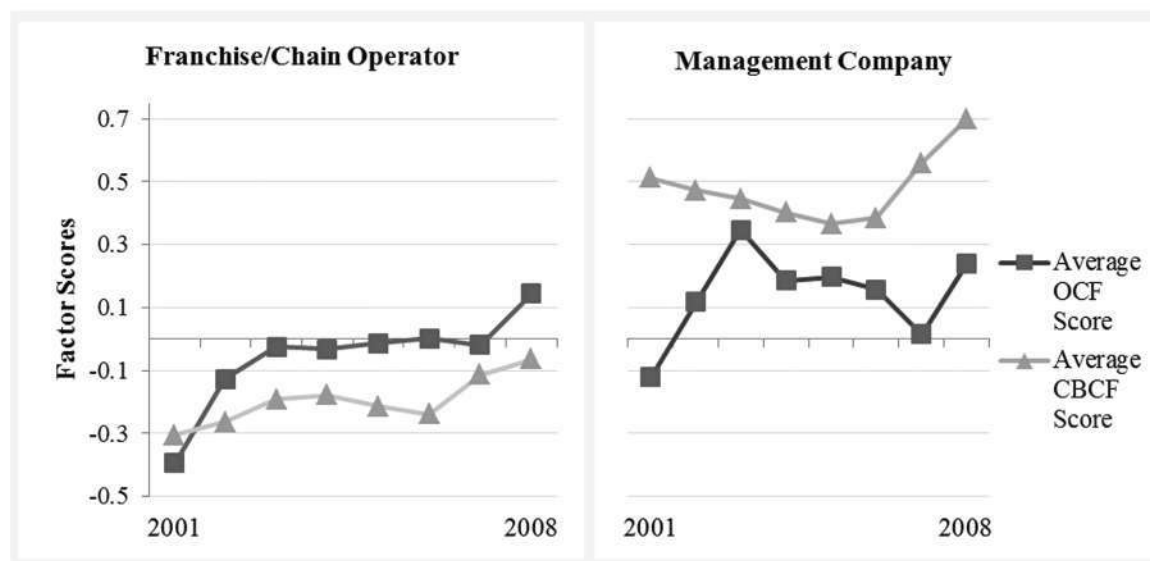
Discussion and Managerial Implications

In this study, we set out to develop a consistent quantitative measure of ES. The prolonged controversy between the green-pays and the pay-to-be-green camps will benefit from a standardized metric that measures economic and environmental performance simultaneously. Using the hotel industry as our research setting and normalizing five resource expenses by RevPAR, we obtain a measure of resource efficiency, which corresponds one-to-one with the resource productivity principle (Lovins and Lovins 2001). Moreover, because the input data are third-party-verified yearly operating costs, this measure meets the criteria of sustainability indicators (Harger and Meyer 1996)—simple, covering environmental and economic issues, quantifiable, and sensitive to trends and change.

More specifically, we identified two principal factors that drive the utility and materials expenses in hotel operations. OFC is found to have larger weights from costs assigned to accounts that seem largely at the discretion of hotel management, in terms of volume: electricity, water and sewer, and “maintenance other” expense. By contrast, CBCF is connected to laundry, linen, and supplies in both rooms and F&B services, which relate more to customers’ activities. This two-factor ES measure underscores the importance of taking both operations-centered and customer behavior-centered factors into consideration when implementing ES initiatives. A case in point is the Willard InterContinental Hotel, in Washington, D.C. (Houdre 2008). In 2007, the Willard set specific goals to reduce consumption of electricity, natural gas, and water. Despite significant efforts in reducing resource consumption in operations, actual usage exceeded the targets by more than 10 percent. In addition to a 5 percent business increase in that year, the opening of a new restaurant was also responsible for the increase in resource consumption. The Willard InterContinental Hotel’s experience is consistent with the patterns we observed in the exhibits where the resource intensity of F&B service creates challenges for managing resource efficiency.

We observed systematic variations in the ES benchmark along key dimensions of hotel characteristics. In particular, as the chain scale of a hotel goes up, the CBCF scores increase. The OCF scores, on the other hand, decrease when moving up market (say, from midtier without F&B to upper-tier without F&B, or from midtier with F&B to upper-tier with F&B). There may be a sweet spot for resource efficiency in the mid- to upper-tier without F&B segments, where both factor scores are negative (i.e., more resource-efficient than the sample average).

The hotel operating structure is also a key consideration in sustainable development. We found that hotels run by management companies scored higher in both factors (i.e.,

Exhibit 11:**Longitudinal change in environmental sustainability (ES) factor scores by operating structure**

lower resource efficiency) than those run by franchise or chain operators. One possible explanation is the composition of chain segments in each group. The franchise- or chain-operated hotels have a higher concentration of hotels with no F&B services, which generally have CBCF scores near or below the average, as opposed to hotels run by management companies, which tend to have much higher CBCF scores. More rigorous statistical analysis will prove helpful in separating the effects of chain segment and operating structure.

Location-related characteristics are central to ES because climate and population are the two most important issues in sustainable development. We found a low correlation between the heating and cooling degree days and the factor scores in our sample, indicating influences from other hotel characteristics such as market segment and property type. This outcome also suggests that sustainable resource management should go beyond energy efficiency. Furthermore, we found that urban hotels operate more efficiently in spite of the high resource price and scarcity in urban settings, which means that adversity in a locale is not a major factor in determining resource efficiency. Rather, market mechanisms, such as competition, and policy mechanisms, such as state or city environmental regulations, can significantly affect resource efficiency.

Longitudinal analysis reveals that operations-centered resource efficiency is more sensitive to industry downturns. Despite the shift toward sustainability in the hotel industry beginning about 2005 (CHR 2009), the operations-centered resource efficiency still worsened after the housing bubble burst. This suggests that the timing of ES initiatives aiming

at improving operations-centered resource efficiency is crucial. It is necessary to focus on resource efficiency during downturns, but the momentum is more likely to be sustained if the ES initiative is implemented during prosperous years and therefore more likely to secure general buy-in by showing positive results. On the other hand, ES initiatives aimed at influencing customer behavior to improve resource efficiency should be consistently carried out on a continuous basis.

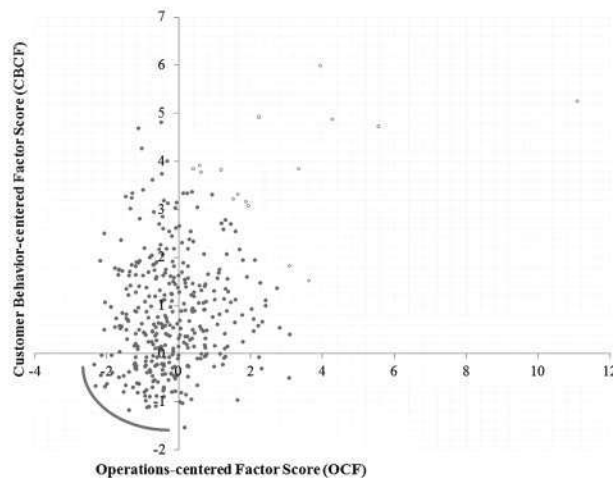
A Benchmarking Tool for Managers

To apply this benchmarking tool in decision making, a hotel manager can first establish a baseline of the hotel's ES profile using the most recent operating statement. This profile can then be updated periodically to capture both systematic and random variations in ES. Based on these quantitative snapshots, the impact of current green practices can be measured, and the practices can be improved. For future green projects, the cost-benefit analysis can be conducted on verified data and expressed in solid terms. During implementation, the actual effects can be tracked and quantified, leading to a better understanding of the distinctive characteristics of the hotel and its customers.

Moreover, hotel management can identify and disseminate the best practices by benchmarking across a class of hotels. Exhibit 12 depicts the ES factor scores for the upper-tier hotel properties with F&B. Each dot in the graph represents a hotel's eight-year average of the OCF score (*X*-axis) and the CBCF score (*Y*-axis), with the hotels in the lower left quadrant achieving the highest resource efficiency on

Exhibit 12:

Environmental sustainability (ES) profile for upper-tier with food and beverage (F&B) hotels ($N = 389$, 2001–2008 average)



both dimensions. The red curve traces the “best-in-class” hotels. These hotels can serve as centers of excellence and disseminate their innovations in ES. We note that the best-in-class represents the upside of the variability and may prove valuable for issues with high strategic uncertainty (Raynor 2007). Hotels in the far upper right lag in ES performance. They are exposed to increased risk from fluctuations in resource prices and shifts in customer preferences due to inefficient resource usage. These hotels can benefit the most from best practices diffusion.

Further Research

This descriptive study has opened up several future research possibilities. In this section, we briefly discuss two projects that aim to contribute normatively to sustainable development in the hotel industry. The first ongoing research project investigates the relationship between cost-based resource efficiency and gross operating margin. The goal is to tease out the nuanced effects of several hotel operating characteristics. For example, in this study’s cross-sectional comparisons, we observed that the chain segment and the operating structure both seem to vary with the ES measure. Such intuition obtained through the exploratory work in this paper is rigorously tested using a stochastic frontier analysis (SFA) (Aigner, Lovell, and Schmidt 1977; Meeusen and van den Broeck 1977) panel analysis model (Battese and Coelli 1995), producing estimates of the effect sizes of key hotel characteristics and external forces. SFA uses the actual performance of the most efficient hotels as the “frontier” against which other hotels are compared,

which formalizes the investigation into the “best-in-class” performance illustrated in Exhibit 12. A managerial application of this project involves monitoring efficiency change over time and managing the contributing operating characteristics in the process.

Another ongoing research project delves into the incentive mechanisms along the service supply chain consisting of hotel owner, operator, and guests. Research has underlined the importance of involving hotel owners (Butler 2008) and corporate customers (F.L.C. 2000) in sustainable development, which corresponds to an important realization from current study—namely, the correlation between resource efficiency and operating structure. Hotel operating structure is essentially a contractual relationship that ties together the fate of the owner’s investments, the management company’s policies and operating procedures, and the chain’s brand equity. To understand this relationship, we bring together the contract theory, principal-agent perspective, and customer service coproduction research in this project. Our goal is to identify appropriate incentive mechanisms for investing in environment sustainability when the payoff scenarios, customer involvement, and nature of the service processes vary.

In conclusion, this study’s focus was to understand the underlying driving forces of resource efficiency in service operations. The findings of our study demonstrate the importance of managing both operations and customers in order to coproduce balanced environmental-economic outcomes. As such, we hope this research serves as a starting point for future investigations of ES involving efforts from multiple business functions and organizations. The emphasis on ES and the rich data in the hotel industry present an excellent setting to investigate ES-related issues, and the knowledge gained can benefit the service sector more broadly.

Acknowledgments

The authors would like to acknowledge that they received a research grant from Cornell Center for Hospitality Research (CHR) to cover some of the expenses associated with the execution of this research. The authors wish to sincerely thank the CHR and PKF Hospitality Research (PKF-HR) for their invaluable industry insights and data support. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of CHR or PKF-HR.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Note

1. We made slight adjustments to ensure data comparability by accommodating changes in the USALI and in PKF-HR's data that began with 2007 data. These changes affected three expense items, namely, the laundry-related services for rooms, F&B, and maintenance other expenses. The new measures gathered certain expenses into these categories that formerly were separate.

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